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Taxonomic reassessment of *Zale lunifera* (Hübner) (Erebidae, Erebinae)

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Abstract

In light of the recent discovery of an unrecognized species within nominal *Zale lunifera* (Hübner), the taxonomy of *Z. lunifera* is reassessed. *Zale intenta* (Walker), **stat. rev.** is the name that applies to the widespread species previously called *Z. lunifera*. *Zale lunifera* sensu stricto is the species previously thought to be undescribed; it occurs from the southern Atlantic coastal plain northward to the pine barrens of north-eastern United States. A differential diagnosis and adult illustrations of the two species are given.

Keywords

Zale intenta, Ophiusini, conservation, Atlantic coastal plain, Pine Barrens

Introduction

While curating *Zale* specimens collected on a field trip to south-eastern Georgia, I became aware of two similar but apparently different species collected on the same night. Further comparison to other specimens revealed that both species had traditionally been going under the name *Zale lunifera* (Hübner), but a second, apparently unnamed taxon had recently been flagged as one of conservation concern in the north-eastern United States (Wagner et al. 2003, NatureServe 2009). Comparisons of genitalic struc-

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ture, phenotype, DNA barcodes of the putative species, and examination of the name-bearing types of the subjective synonyms of *Z. lunifera* show that names are available for both taxa. The purpose of this paper is to clarify the taxonomy and provide a diagnosis of these species.

Methods and materials

Adult genitalia were prepared following the methods detailed by Lafontaine (2004).

Molecular variation was assessed based on the 658 base-pair 'barcode' region of the first subunit of the cytochrome oxidase (*cox1*) gene (Hebert et al. 2003). DNA was extracted from one leg removed from a dried specimen, and processed at the Canadian Centre for DNA Barcoding, Guelph, Ontario. DNA extraction, amplification and sequencing protocols for the Barcode of Life initiative are given in Hebert et al. (2003). Barcode haplotypes were compared with phylograms constructed using the neighbour-joining method as implemented on the Barcoding of Life Data Systems (BOLD) website (http://barcodinglife.org; Ratnasingham and Hebert 2007). Phyletic distances were calculated using the Kimura-2-Parameter (K2P) distance model. Data for molecular voucher specimens, including trace files and photographs, are available at the BOLD website under the project: Lepidoptera of NA Phase II: "*Zale lunifera*" under the "Published Projects" tab).

Abbreviations of collections referred to herein are as follows:

AMNH American Museum of Natural History, New York, New York, USA

BMNH The Natural History Museum (formerly British Museum [Natural History]), London, UK.

CNC Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa, Ontario, Canada

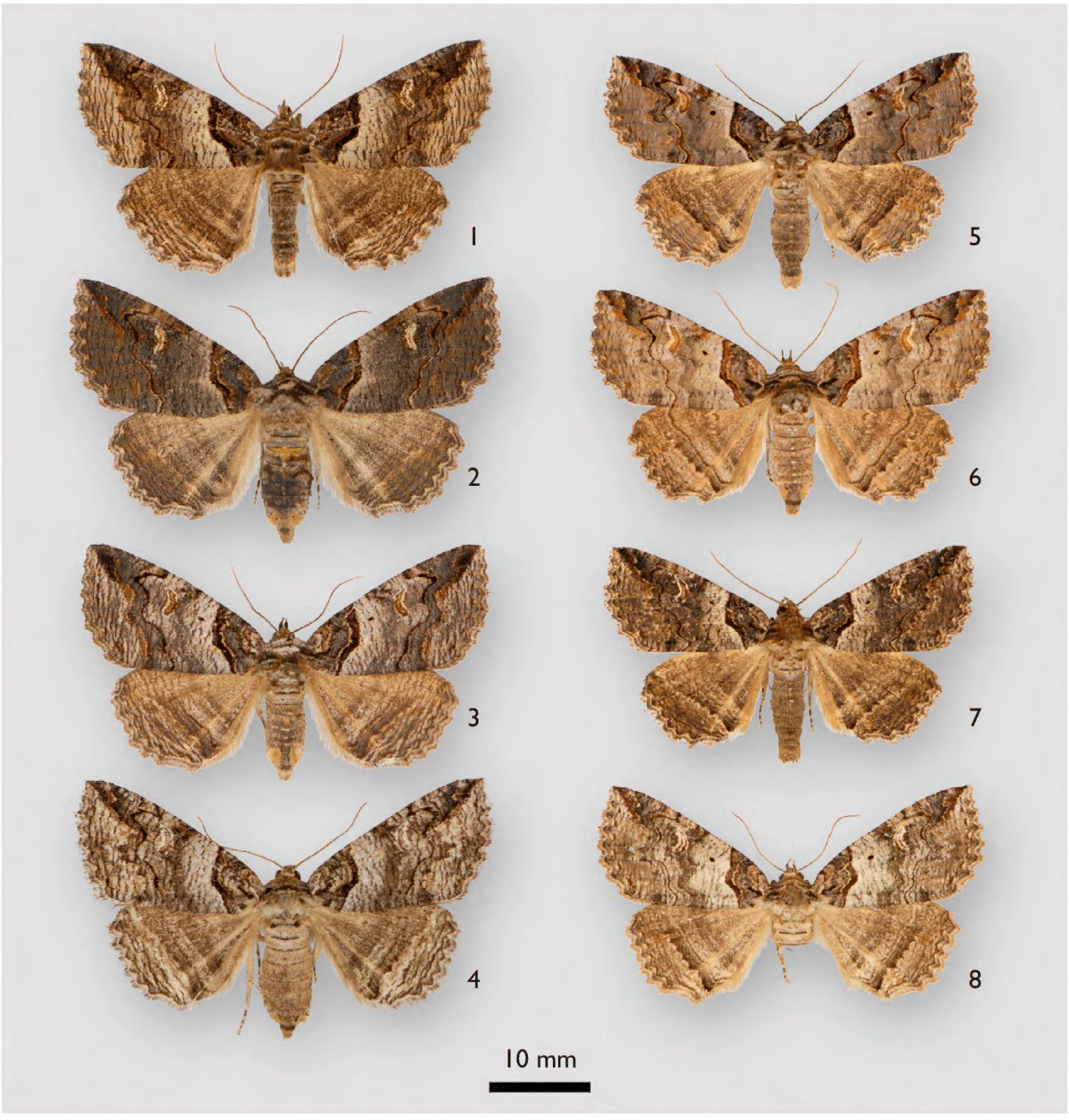
USNM National Museum of Natural History (formerly United States National Museum), Washington, D.C., USA.

Systematics

***Zale intenta* (Walker), stat. rev.**

Figs 1–4

Homoptera intenta Walker, [1858]: 1070.
Homoptera woodii Grote, 1877: 88.
‡ *Zale calycanthata* ab. *dealbata* Strand, 1916. unavailable.
Zale lunifera of authors, not (Hübner, 1818).
Homoptera cingulifera; Holland 1913: pl. XXXVII f. 17.
Zale lunifera; Handfield 1999: p. 71 f. 8713; Rockburn & Lafontaine 1976: 144, fig. 551.



Figures 1–8. Comparison of adult *Zale intenta* and *Zale lunifera*. **1** *Z. intenta*, Edmunston, NB **2** *Z. intenta*, Stony Swamp, Ottawa, ON **3** *Z. intenta*, Ithaca, NY **4** *Z. intenta*, Ludowici, GA **5** *Z. lunifera*, Dwarf Pine Plains, Suffolk Co., NY **6** *Z. lunifera*, Lakehurst, NJ **7** *Z. lunifera*, neotype, Ludowici, GA **8** *Z. lunifera*, Anthony, Marion Co., Anthony, FL.

Type material. *Homoptera intenta* - type locality St. Vincent [Florida?] acc. to type label.; holotype in BMNH [photograph examined]. The wing pattern of the holotype is closest to that of southeastern United States populations of this species, which have a more greyish, contrasting pattern (particularly the hindwing) and more contrastingly pale subterminal forewing area than more northern specimens of this species and of *Z. lunifera*. *Homoptera woodii* - Type locality "[USA:] N[ew] Y[ork], Center." Holotype in BMNH [photograph examined]. *Zale calycanthata* ab. *dealbata* – unavailable infrasubspecific name. Although some of Strand's infrasubspecific names have subsequently

been validated (most of them inadvertently), I have found no evidence of this for *dealbata*. McDunnough (1938) listed it as a "form" (of *Z. calycanthata* (Smith)), not as a subspecies or subjective synonym. This name is not included in Franclemont and Todd (1983) or Poole (1989), presumably because it was deemed to be unavailable.

Other material examined. New Brunswick: Edmunston; St.-Basile; **Québec:** Temiscouata Co.; Ste. Flore, Lac Mondor; St-Mathieu de Beloeil; Manseau; Harrington Lake, Gatineau; Aylmer; Kirks Ferry **Ontario:** Ottawa, Pinhey Forest; Carp; Pike Lake, Manitoulin Island. **Tennessee:** Sevier Co., Great Smoky Mountains National Park. **Georgia:** Long Co., Ludowici, Griffin Ridge. **Maryland:** Beltsville. **Massachusetts:** Forest Hills. **Pennsylvania:** Indiana; Berks Co., Sinking Spring. **South Carolina:** McClellanville, Wedge Plantation. **New York:** Ithaca. **Louisiana:** Caddo Parish.

Diagnosis. This species has long been confused with *Z. lunifera*, from which it differs by its larger size, more elongate forewing shape, the poorly defined or absent black orbicular spot, and the less sinuate black antemedial line on the forewing. *Zale intenta* also has a tendency to develop an overall striate pattern that is very poorly or not at all developed in *Z. lunifera*, particularly well developed in south-eastern populations (Fig. 4). Male genitalic differences are slight; the valves are more elongate and the aedeagus is longer with a slightly greater twist in *Z. intenta* than in *Z. lunifera*. In females, the distance between the ostium and the caudal margin of the antevaginal plate is equal to the diameter of the ostium; in *Z. lunifera*, this distance is 2.0–2.5 × the diameter of the ostium.

Redescription. *Head* – antenna ciliate in both sexes; palpi and head dark brown. *Thorax* – thoracic collar dark brown with a fine black basal line and light-grey distal border; middorsal area with a brown anterior and posterior tuft, scales prominently light grey distally bordered basad by fine black line; tegulae patterned similarly, but with a broad black basal patch; thorax fuscous grey brown ventrally. *Abdomen* – dorsum and ventrum brown grey; dorsum of segments four to seven with pale-tipped hair tufts; sexes similar. *Forewing* – length averaging 19.7 mm (n = 6) in males, 20.1 mm (n = 3) in females; ground colour greyish brown to dark chocolate brown, with a slight dark-purple tinge in fresh specimens; entire wing covered in fine, black striae (particularly developed in southern populations); basal area (basad of antemedial line) dark brown, contrasting with remainder of wing, with small paler brown patch at base of costa; antemedial line dark brown to black, sometimes paler brown medially; bordered distally by pale grey-brown shading; orbicular absent or small and black; reniform spot rust brown centrally with a fine black border and a broader pale-tan outer border; postmedial line fine, black and sinuate; subterminal area variously concolorous with postmedial area (usually) or paler grey-brown, particularly in south-eastern populations; ventrum even fuscous brown with slightly darker indistinct reniform and costal part of postmedial line; dark striae less distinct than on dorsum; sexes similar. *Hindwing* – ground colour greyish brown to dark chocolate brown, grading to lighter fuscous brown toward costal margin; entire wing covered in fine black striae; medial area with or without an indistinct double medial line; postmedial line absent or indistinct; ventrum even fuscous brown with slightly darker, indistinct, dark discal spot;

dark striae less distinct than on dorsum; sexes similar. *Male genitalia* – valves symmetrical, apex (cucullus) distinctly lanceolate and curving about 90 degrees inward; saccular extension consisting of a low triangular process; saccular process an indistinct ridge; uncus long and cylindrical, approximately half length of base of valve, apex pointed and down curved; juxta slightly asymmetrical, with left caudal margin developed into a slight lobe; aedeagus curving dorsad and to right by approximately 90 degrees; aedeagus with a lobe-like process at distal margin; vesica roughly globose with numerous diverticula, very finely scobinate. *Female genitalia* – papillae anales bluntly triangular, lightly sclerotized; posterior apophysis 2.2 × length of papillae; anterior apophysis 1.0 × length of papillae; antevaginal plate deeply divided by a medial notch, forming a quadrate flange on each side; ostium originating near proximal margin of antevaginal plate, separated from caudal margin of plate by 2.0–2.5 × diameter of plate; ductus bursae short, 2.0–2.5 × as long as diameter of ostium; corpus bursae pear shaped, proximal, larger chamber with minute, internal spicules.

Distribution and biology. Distributed from Nova Scotia (Ferguson 1954) westward to Wisconsin (Forbes 1954) and Missouri and southward to Georgia. Likely also occurs in northern Florida, but literature records may apply to *Z. lunifera*. The southwestern range limit is not known. Larvae feed on *Prunus* species, including black cherry (Forbes 1954), beach plum and "cherry" (Wagner 2005). The flight period is from March to June depending on latitude and elevation.

***Zale lunifera* (Hübner)**
Figs 5–8

Phaeocyma lunifera Hübner, 1818: 19, pl. XX.
Homoptera cingulifera Walker, [1858]: 1056.
Zale lunifera; Covell 1984: pl. 38 f. 21.

Type material. *Phaeocyma lunifera* – Type locality: "Georgien" [USA: Georgia]; the type is apparently lost, but the illustration in the original description is most similar to the oak-feeding species, with a more brownish colouration, distinct orbicular spot, indistinct striations and even, slightly violaceous submedial forewing area. In contrast, specimens of *Z. intenta* from coastal Georgia tend to be heavily striate, greyish rather than brown, and with a contrastingly pale subterminal forewing area. To ensure the stability of the name, the following specimen is designated as **neotype**: "USA: GA [Georgia] Long Co., Ludowici, / 3 mi SW, Griffin Ridge / WMA. [Wildlife Management Area] 31.694N -81.796W / 6-iii-08 C.Schmidt & J.Adams"; "NEOTYPE / Phaeocyma / lunifera Hübner / desig. Schmidt 2010". *Homoptera cingulifera* – Type locality: [USA:] East Florida; holotype in BMNH [photograph examined].

Other material examined. Florida: Marion Co., Anthony; Putnam Co., Ocala National Forest. **North Carolina:** Craven Co., Croatan National Forest. **New York:** Suffolk Co., Dwarf Pine Plains**. New Jersey:** Lakehurst. **Georgia:** Long Co., Ludowici,

Griffin Ridge. **Massachusetts:** Plymouth Co., Myles Standish State Forest. **Alabama:** Ozark, Camp Rucker.

Diagnosis. Similar to *Z. intenta*; see diagnosis under that species.

Redescription. Markings, colouration and genitalic structure as for *Z. intenta*, but differing in the following characters. *Forewing* – length averaging 17.4 mm (n = 4) in males, 18.9 mm (n = 3) in females; ground colour greyish brown to dark chocolate brown with a slight violaceous tinge; entire wing covered in fine black striae, less developed and thinner than in *Z. intenta*; antemedial line with more pronounced medial angle than in *Z. intenta*; orbicular small and black, sharply contrasting; subterminal area concolourous with medial area, never contrastingly paler with strong striae. *Hindwing* – as for *Z. intenta*, but without variation toward more contrasting hindwing markings seen in pale specimens. *Male genitalia* – valves slightly more elongate compared to *Z. intenta*; aedeagus slightly shorter and less twisted than in *Z. intenta*. *Female genitalia* – ostium separated from caudal margin of antevaginal plate by diameter of ostium; proximal chamber of corpus bursae 1.9 × diameter of distal chamber.

Distribution and biology. *Zale lunifera* occurs primarily east and south of the Appalachian Mountains. Examined material and reliable records indicate a range from southern Maine (Wagner et al. 2003) south to Lee Co., Mississippi (D. Schweitzer, pers. comm.) and Florida. Not known from south-eastern Virginia or South Carolina, but the species may occur in these regions. Lack of suitable habitat in Maryland and Delaware make occurrence in these states unlikely (D. Schweitzer, pers. comm.). Occurs inland to the mountains of Virginia and Lebanon County, Pennsylvania (NatureServe 2009).

In southeastern Georgia this species inhabits open, sandy pine-oak forest. Wagner et al. (2003) record it from sand plain pitch pine / scrub oak barrens in northeastern United States. Larvae feed on Bear Oak (*Quercus ilicifolia* Wangenh.) (Wagner et al. 2003), and other scrub oak species (NatureServe 2009). Additional life history data are given by NatureServe (2009).

Remarks. DNA analysis of seven *Z. lunifera* specimens (New York, North Carolina, Florida) exhibited two 'barcode' haplotypes differing by one base-pair. Minimum divergence from *Z. intenta* haplotypes (five specimens from Quebec and Tennessee) was 1.2 %.

Discussion

The taxonomy of *Zale lunifera* (in the broad sense) has not been clear. Forbes (1954) recognized one valid species, but correctly diagnosed "southern specimens of *Z. cingulifera*", i.e., *Z. lunifera*, as differing from *Z. intenta* in the more irregular forewing lines, stronger and more dentate subterminal line, and less striate pattern. All *Z. lunifera* group names were treated as synonyms of *Z. lunifera* in Franclemont and Todd (1983). Subsequently, Wagner et al. (2003) treated *Z. lunifera* as "*Zale* sp. 1 near *lunifera*," as it was thought that nominate *Z. lunifera* was the more common and widespread spe-

cies. As discussed above, the name *Z. intenta* applies to the widespread species, whereas true *Z. lunifera* is the species with a more restricted occurrence east and south of the Appalachians.

The global conservation rank currently assigned to *Z. lunifera* is G3G4, or "Vulnerable" to "Apparently Secure" (NatureServe 2009). Additional surveys for this species should be carried out in the Appalachian Mountains (particularly the eastern portion), sand hills and coastal plain south of New Jersey, which would probably show this specise to be more widespread than currently known.

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